

COMPUTER WORKSHOP

INTRODUCTION

The power consumption of PCs is worth investigating if you want a very small or quiet computer, or you simply want to save electricity. But while appliances such as washing machines and fridges provide detailed information on power usage, getting equivalent data for a PC is a headache.

The problem is that no-one has done a thorough investigation into PC power consumption. You can get figures for each component, but actual consumption varies wildly according to what your PC is doing. Similarly, you can measure a PC's total consumption using an in-line power meter, but this tells you nothing about which components are being greedy.

Without reliable figures, tasks such as buying a suitable power supply unit are reduced to guesswork. The only way to play safe is to buy one that's hugely overspecified, such as the latest 1,000W beasts.

Computer Shopper relishes a challenge, so this month we've performed an in-depth investigation into PC power consumption. We'll show you what really eats up the amps in your PC.

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PC power consumption

Knowing how much power your PC consumes could help you save money and the planet. Chris Finnamore goes green

Measuring how much power your PC's power supply unit (PSU) draws is easy. Finding out which components ultimately use that power is a good deal harder. Over 40 wires lead from the PSU, each of which can carry current to or from components.

Of these 40 wires, 24 lead to the 24-pin motherboard connector. This includes two 12V wires, five 5V wires, four 3.3V wires, a 12V wire and a 5V standby wire, which keeps supplying power to the PC when it's switched off. The rest of the wires are returns or unused. The supply also powers an auxiliary four-pin connector with two 12V wires and a six-pin PCI Express connector with three 12V wires. These cater for your processor and graphics card respectively. There's a group of four-pin Molex connectors, which have one 12V wire and one 5V wire and are used to power older hard disks and all but the newest optical drives. The SATA connectors, which are used for modern hard disks, have a 3.3V wire, a 5V wire and a 12V wire.

BREAK IT DOWN

To measure the power delivered by each wire, we needed to check how much current each carries. This meant temporarily breaking each wire and bridging the gap with an ammeter. To do this easily we used an electronics breadboard, which is usually used for building logic circuits, and a set of breadboard bridge wires. A breadboard consists of two or more rows of electrical contacts separated by an insulated gap. After looking at the power supply's manual to see which wire provided which voltage, we plugged the power connectors from the power supply into one side of the breadboard and the PC's components into the other side, then bridged all the contacts so that every wire from the power supply was connected. We could then remove any bridge and replace it with an ammeter to measure the current in the associated wire.

We had some idea which wires powered which components, but to be extra sure we devised a set of tests to stress each part of the PC. To stress the processor and memory, we used Hot CPU Tester from www.7byte.com, which has both processor and memory stress tests. To further test the processor, we used the *Shopper* video-encoding benchmark. To stress the PC's graphics card, we ran our intensive Call of Duty 2 game benchmark, and we copied files from the hard disk back to itself and from the optical drive to the hard disk to see how much power the storage devices used. We also measured the amount of power the PC was drawing from the mains during each test. We knew from previous tests that our PSU was around 80 per cent efficient, so the power carried away from the PSU by the wires should account for around 80 per cent of the mains power. This enabled us to check that our power consumption results were accurate.

We started by removing the bridge wires one at a time and measuring the current in each wire. As volts x amps = watts, the measured current multiplied by the wire's voltage would give us the power in watts drawn on that wire. After testing each wire with the PC idle, we saw that the results were far too low. The total

power used by the PC's components came to just over 30W, while the PSU was drawing 110W from the mains. No PSU is that inefficient, so we knew something must be wrong with our measurements. We concluded that the ammeter must be providing too much resistance so that when we inserted it, current was diverted down other wires. To test this, we wired the ammeter between one of the 24-pin motherboard connector's 12V wires, and removed the other wire's bridge so the current would have nowhere to go but through the ammeter. The current shot up from 0.18A to 1.57A, which was far more realistic. We eventually removed most of the bridges for the 24-pin connector, leaving just one wire of each voltage remaining, then wired the ammeter across those remaining wires. The PC worked perfectly with just one 12V, one 3.3V and one 5V wire connected on the 24-pin ATX connector. Next we connected just one 12V wire on the four-pin motherboard and six-pin PCI Express connectors. We wouldn't vouch for the PC's long-term stability with just one wire for each voltage plugged in, but it managed to get through our benchmarks.

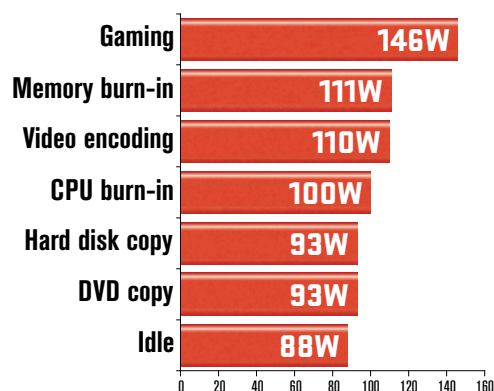
MEASURING POWER CONSUMPTION

Once we had ensured that we were detecting all the current at each voltage, our results made sense. The PC's components were using 88W at idle and the PSU was drawing 110W from the mains, which tallied with the PSU's 80 per cent efficiency. We could now begin our investigations in earnest.

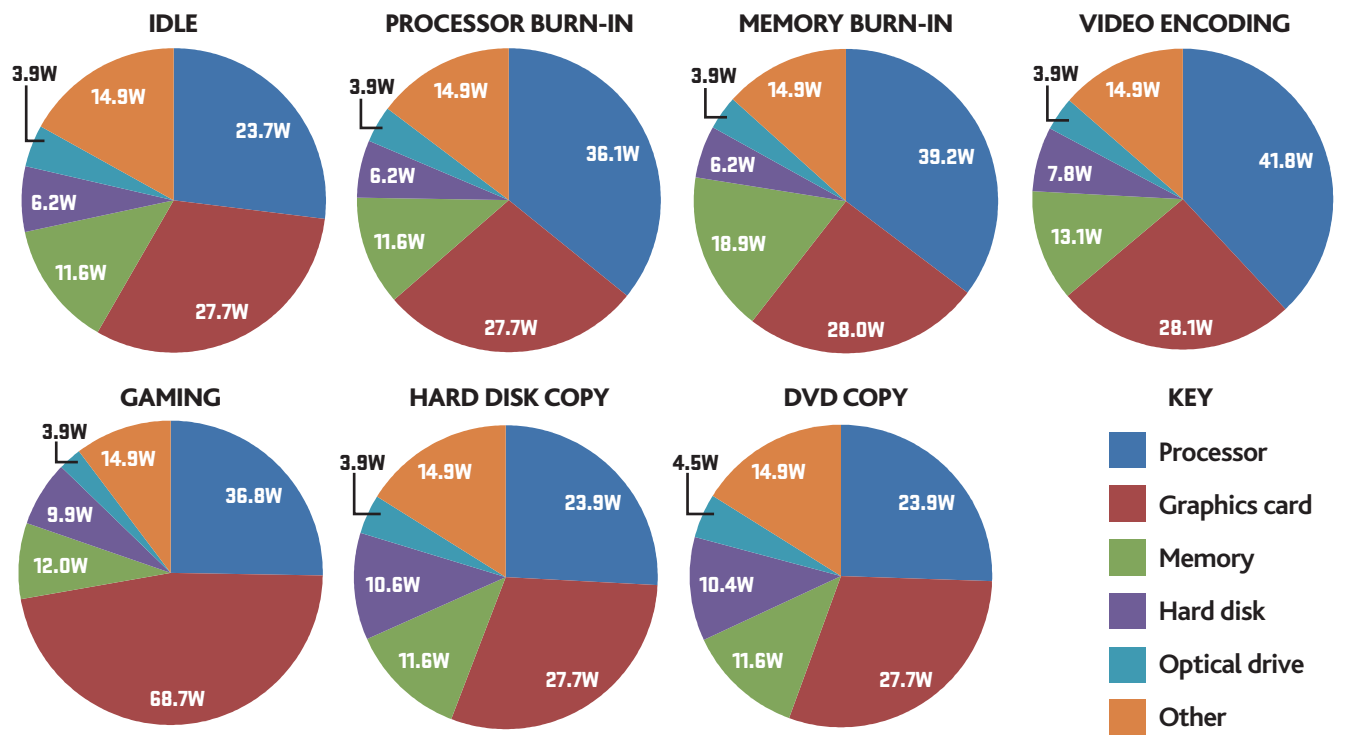
We chose a test PC with a medium specification: a 1.66GHz dual-core Intel E2140 processor, 1GB of DDR2 memory, an ATI Radeon X1950 Pro graphics processor, a 7,200RPM SATA hard disk and a DVD writer. It was powered by a 500W Hiper PSU with two 12V rails.

We now put this PC through each of our stress tests and compared the power used by each wire with its consumption when the PC was idle. First we tested the 12V wires on the 24-pin connector. Power consumption on these wires was the same in all tests except gaming, where more power was used, so the 24-pin connector's

Total power consumption



▲ Tasks that really tax the power-hungry processor and graphics card consumed the most power in our tests

Power sharing Which components draw the most power for different tasks

12V wires seem to power the graphics card's PCI Express slot. The 5V wires on the 24-pin connector used far more power in the memory burn-in test, and a little more in video encoding and gaming, so they seem to power the PC's memory. The 3.3V wires used the same amount of power at all times, so would appear to power general circuitry on the motherboard.

Next we tested the four-pin processor connector. As this is designed to provide power to the PC's processor, it's no surprise that it supplied more power during the processor burn-in, video-encoding and game tests. The PCI Express graphics card connector used the same amount of power in all tests except gaming. The four-pin Molex connector plugged into the optical drive drew slightly more power from its 12V wire during the DVD copy test, and significantly more from its 5V wire. Finally, the SATA connector plugged into the hard disk didn't use any 3.3V power but almost doubled the power drawn from its 5V and 12V rails during the hard disk copy and DVD copy tests.

THE RESULTS

We could now work out each component's consumption at idle and during each test. The pie charts above show the results at a glance.

At idle, the processor and graphics card had the lion's share of the power, requiring 23.7W and 27.7W to display the Windows desktop. The memory took 11.6W of the total, while the hard disk drew 6.2W and the optical drive just 3.9W. The rest of the motherboard's circuits used 14.9W, as they did in all tests.

The processor burn-in test puts a heavy load on the processor, and its power consumption increased from 23.7W to 36.1W. All other components stayed at their idle levels. The memory burn-in test seemed to use the processor even more than the processor burn-in test, as it consumed 39.2W. The memory needed 18.9W during this test, drawing nearly four amps from the power supply's 5V rail.

The video-encoding test put some strain on the memory, as its power consumption increased by a couple of watts. This test was also the most processor-intensive of all, as the processor needed 41.8W while encoding. We know that our video-encoding software, TMPGEnc, exercises both cores of a dual-core processor, and this could explain the higher figure. The hard disk also drew more power during this test, as the encoding program continually reads a video file from the hard disk, encodes it and writes the destination file. Encoding video used 110W in total, and needed 134W from the mains.

Playing a demanding 3D game is the most intensive task most PCs have to perform, and our results show this. The processor needed 36.8W during the game test, and the graphics card's power consumption increased from 28.1W in the other tests to a sizeable 68.7W. Thanks mainly to the large amount of power the graphics card needs, the total power consumption increased to 146W, with 174W drawn from the mains. The power supply was at its most efficient at this load, delivering 84 per cent of the power it drew from the mains to the PC's components.

The hard disk copy and DVD copy tests were the least power-hungry tasks our test PC had to perform. When copying our test files, the hard disk's power consumption increased from 6.2W to 10.6W. When copying files from DVD to the hard disk, the DVD drive's power consumption increased from 3.9W to 4.5W, but the hard disk still needed 10.4W. This makes the DVD drive the PC's least power-hungry component. The PC needed just 93W during both tests, and drew 119W from the mains.

HOW TO SAVE POWER

It's surprising how much power your PC uses even when it's doing nothing. The processor still uses a fair bit of power, and the hard disk spins even when it's not reading or writing any files. The obvious way to save power is to shut down your PC when you're not using it, but this isn't

always practical. However, there are steps you can take to save power. The first is to adjust Windows' power management settings. In XP and Vista, these are found in the Control Panel under Power Settings. In both operating systems, you can set your hard disks to power down after a set period of inactivity, and they'll spin up again only when you move the mouse or press a key.

Modern processors also reduce their speed when they're not under stress, using less power. Check that processor throttling is enabled in your PC's BIOS. This technology has several names, such as Cool 'n' Quiet on AMD motherboards or SpeedStep on Intel boards. If you have Windows Vista, once throttling is enabled you can set how much your processor slows down in the Power Options by clicking on the Change plan settings link under your currently selected power plan, then clicking Change advanced power settings.

You should also set your PC to go into Standby mode when you're not using it. You can set how long your PC waits before going into Standby in the Power Options. There are two types of Standby, S1 and S3. S1 turns off just the hard disks and monitor, which doesn't save much power. S3 turns off everything but keeps the system state in the PC's RAM, so uses a minimal amount of power. You can choose which Standby mode to use in the BIOS.

Finally, an efficient power supply is essential. There's no point in setting all your components to use less power if a significant percentage of mains power is wasted before it even gets there. Even our 80 per cent efficient power supply wasted 22W of power when the PC was idle, and some cheap generic PSUs are only 70 per cent efficient. If we left our test PC on for a year with a 70 per cent efficient PSU, it would waste 333 kilowatt hours of power, costing £52.28 at London Electricity rates. With a highly efficient PSU such as Corsair's HX520W (*Labs, Shopper* August 2007), which has an average efficiency of 86 per cent, you would waste only 125 kilowatt hours, costing just £20 over the year. **CS**